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# Analyzing the Quantum Based Satellite Communications

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**Abstract**

Quantum computing offers unique solutions applying tools of quantum physics, which are incomparably numerous than those of classical physics. Although quantum computers are the possible application of the far future, a few algorithms are already available for solving problems otherwise difficult to handle with traditional computers. Recently the telecommunication requires large amount of data transfer via satellites. An interesting way of dealing with this problem might be using quantum communication.

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*Keywords:* quantum communications; satellite communications

## 1. Introduction

For an improved satellite communication system we need better hardware, better software and better solution for the transmission - irrespectively of what better means. Due to a convergence between the different technologies, there are a lot of solutions in telecommunications which are coming from other fields like information theory or computer studies. One of the main problems in the field of computer technology is the decreasing size of transistors used during the manufacturing process of the computers.

The quantum computing could give us effective tools and methods [1]. The power of quantum parallelism allows us to solve classically complex problems during a short period of time. The search in an unsorted database is faster with the Grover-algorithm. Quantum cryptography provides new ways to transmit information securely. In today's communication networks, the widespread use of optical fiber and passive optical elements allows of using quantum cryptography in the current standard optical network infrastructure. The Free-space Quantum Key Distribution (QKD) was first implemented over an optical path of about 30 cm in 1991. In 2002, a research group demonstrated that free-space QKD is possible in daylight. In 2006, the distance was further extended to 144 km by an international research group [2]. Free-space quantum communication can be extended to ground-to-satellite or satellite-satellite quantum communication [3] and in 2008, the European Space Agency named the quantum-based satellite communication as one of the most important targets for the next five years. One of the main advantages of using space for future quantum communication is achieving the level of loss-free and distortion-free optical communication.

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## 2. Results

### 2.1. Satellite communications

At present, using optical QKD is limited to a distance of approximately hundreds kilometers, however, free-space quantum cryptography makes it possible transmitting photons over long distances. We examined the physical properties of the Earth-space and space-space channels to give some prescriptions about the possible losses and to give some useful ideas about the implementation of such a channel [5]. We also developed an analytical model which describes a few photons' behavior to simulate the communication process over a satellite quantum channel. Based on our mathematical models, we were able to examine selected parameters of quantum satellite communication. According to our results, the distance between two satellites should be maximum 15,000 km to handle a successful BB84 [1]. These results show that we can realize quantum communication over intercontinental distances. However, after analyzing of LEO (Low Earth Orbit) and GEO (Geostationary Earth Orbit) satellite orbit, we can say that a BB84 supported equipment running on a LEO satellite cannot reach a GEO satellite. We examined the superdense coding in both space-space and space-Earth communication. From our calculations based on the optical losses we can conclude, that deep space links and uplinks cannot be realized with superdense coding. We also examined the BB84 protocol's performance in downlinks. Our results show that satellites at low earth orbit can produce secure keys even at large zenith angles, and hazy weather.

### 2.2. Redundancy-free communications

Another interesting question is related to quantum error correction. Currently many techniques are introduced but in these proposals redundancy is required for successful error correction. If we could use redundancy-free solutions, they would be very useful in the long-distance aerial communication. We developed different redundancy-free solutions for free-space quantum communications. Our protocols achieve the redundancy-free quantum communication using local unitary operations and unitary matrices.

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## Further reading

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